KITE-BORNE ANTENNAS FOR HF PORTABLE OPERATION

Dave Lunn, G3LSL*

DURING THE SUMMER MONTHS I enjoy portable operation on the hf bands, using a Trio TS120V 10W transceiver. A variety of antennas has been tried on these outings, including dipoles and longwires strung between convenient trees, also base-loaded verticals using an 8m telescopic aluminium mast. The latter involves the erection and guying of the pole, which is not an easy single-handed task, while the tree-supported varieties entail considerable physical exertion, not to mention risk to life and limb! In searching for a more convenient method of supporting efficient radiators, the viability of kite-borne antennas was explored. The exercise proved as interesting as it was successful, and the following notes are offered as a practical introduction to the subject for those wishing to try "sky hooks" for themselves.

Although kites are dependent upon the vagaries of the weather, the British climate provides a frequent supply of windy days and there are several kite designs which are suitable for flying in a wide range of wind speeds. Kites generally fold into small, easily-carried packages, and the erection and recovery of a kite-borne antenna is a good deal quicker and easier than its mast- or tree-supported counterpart. In its simplest form a kite-borne antenna comprises a length of light but strong wire which doubles as the tethering line of the kite. However, this arrangement is fairly limiting since the wire assumes a sloping configuration whose angle and direction are fixed by the prevailing wind. More complex arrangements are possible, allowing greater freedom to determine radiation angle and direction.

If kite-borne antenna operation is to be successful, there is a logical sequence of steps which should be followed. The first of these is to choose the type of antenna to be supported, as this will determine the size of kite needed. Once the choice of antenna and kite has been made, it will be necessary to select an appropriate site for "flying operations" and to learn the techniques of kite flying. Finally, there are important issues concerning safety and the observance of Civil Aviation Authority regulations.

*16 Kingsmead, Little Ann, Andover, Hants SP11 7PN.

Antenna types

Reference has already been made to the limitations of using the wire as the tether for the kite. However, this simple approach is still capable of surprisingly good results and is certainly worth trying before graduating to more ambitious configurations. Fig 1(a) shows the recommended arrangement. No insulator is needed at the kite end, for obvious reasons, but the base-end insulator should be strong enough to easily withstand the mechanical pull of the kite. The length of the wire can be a half-wave at the operating frequency for voltage-feed, or a quarter-wave for low impendance current-feeding. The former is to be preferred, as it saves the need for a system of radials to provide the low impendance earthing arrangement needed for quarter-wave antennas.

An alternative to the end-fed arrangement is the sloping dipole, shown in Fig 1(b). This confers no advantage over the end-fed wire and, in light winds, will exhibit a marked sag in the middle due to the weight of the centre insulator and feeder. A more attractive variant is to support the centre of the dipole rather than one end, thus producing the popular inverted-V antenna (Fig 1(c)). Two ground anchoring points are needed for this arrangement, in addition to that for a tethering line; one immediate advantage being that a degree of directivity can be achieved by moving the two anchor points around so as to place the antenna broadside on to the required direction of fire.

Omni-directional, low-angle radiation on the higher frequency bands demands a relatively vertical radiator, and this is obtained by once again flying the kite on a separate, non-conductive line. The antenna wire is then dropped straight down from the kite to the operating position (Fig 1(d)). In practice this is best accomplished by first flying the kite to the desired height and then moving the lower end of the wire until it hangs vertically. It will be found that the wire will exhibit a distinct bowing shape, due to the sideways pressure of the wind, but this appears to have little effect on the radiation pattern. Once again, if a quarter-wave radiator is used, ground radials will need to be laid out from the base of the antenna. A much better option is to use a length which is an odd number of 1/8 wavelengths. This will result in an intermediate value of

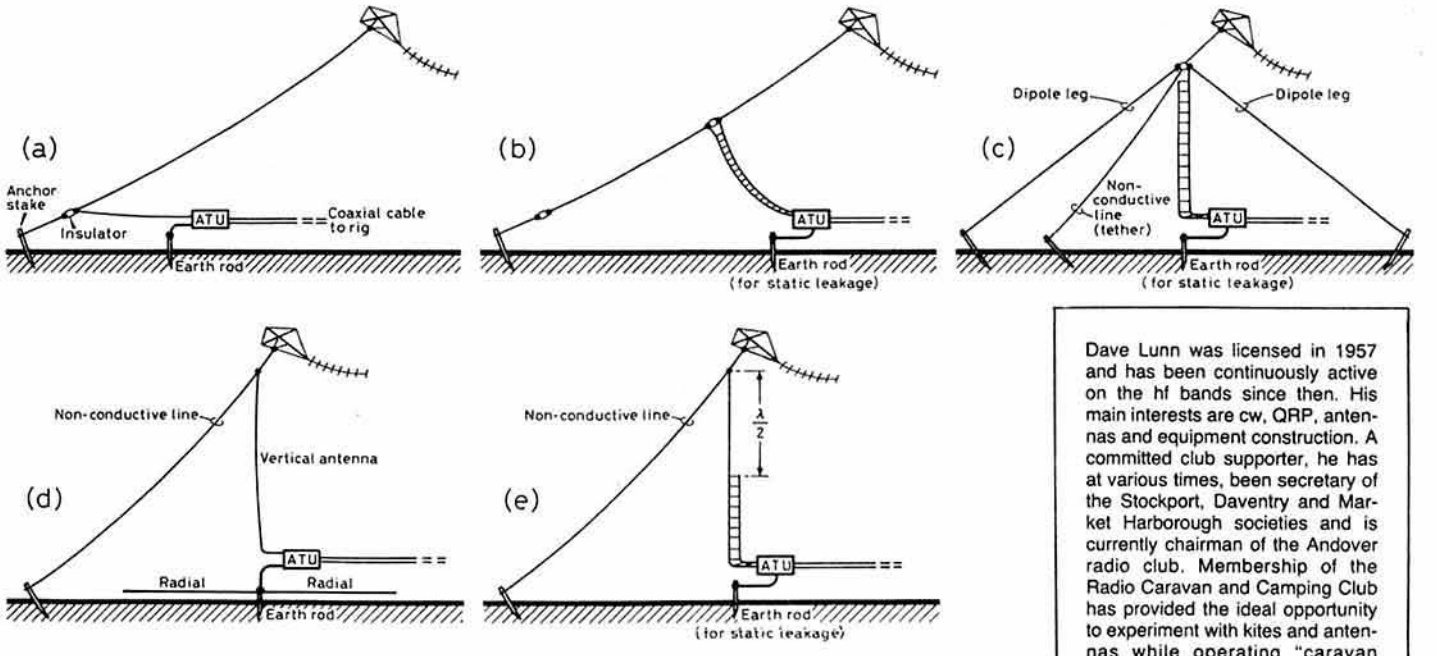

Fig 1. Some examples of kite antennas. (a) Simple wire tether antenna. (b) Sloping tether dipole. (c) Inverted-V. (d) Suspended vertical antenna. (e) Vertical Zepp

Dave Lunn was licensed in 1957 and has been continuously active on the hf bands since then. His main interests are cw, QRP, antennas and equipment construction. A committed club supporter, he has at various times, been secretary of the Stockport, Daventry and Market Harborough societies and is currently chairman of the Andover radio club. Membership of the Radio Caravan and Camping Club has provided the ideal opportunity to experiment with kites and antennas while operating "caravan portable".

feed impedance and avoid the need for a high-efficiency earth connection. For antennas with intermediate or high feed impedances, an earth rod driven into the ground will usually suffice, though ground conductivity obviously plays an important part.

One antenna type which avoids the need for an earth connection, (though a static leakage path should still be provided), is the Zepp (Fig 1(e)). This antenna has a mixed following among the amateur fraternity but can be very effective with the right feeder length and atu type. The diagram shows that the radiating portion can be raised well above ground level, avoiding absorption by nearby objects and also enhancing low-angle radiation. Although the normal, horizontal Zepp can be used on multiples of the frequency at which it is a half-wavelength, this is to be avoided in its vertical form. The reason is that radiation for a half-wave Zepp is generally at 90° to the run of the wire, whereas at multiples of half-waves its lobes tend to lie much more in line with the wire, which would cause power to be radiated upwards and downward rather than horizontally.

Many other types of wire antennas may be kite-supported, and the various handbooks are a useful source of ideas and of data relating to radiation characteristics, feed impedance, dimensions etc. The range of antenna types described will require different forms of matching to obtain maximum efficiency. If resonant dipoles are used, lightweight coaxial feeder would enable direct coupling to the transmitter output. Voltagefed antennas and those of random length, which may present "awkward" impedances, are best fed via a tapped tuned-circuit atu. This enables working Q to be controlled and also provides a dc path to ground for any static charges. Non-resonant dipoles and Zepps, fed with open-wire line, require a balanced feed which is usually achieved by means of a coupling coil in the atu. In such cases it is essential to provide a dc leakage path between the feeder and ground, which can be arranged by connecting a 50kΩ 1W resistor from one leg of the feeder to the earth point. Failure to do so could result in unpleasant shocks from accumulated static build-up.

Needless to say, all materials used in the construction of kite-borne antennas should be as light as possible, consistent with adequate strength. An ideal wire type is that made from thin copper tinsel, braided over a stranded nylon core. An alternative is the thin, stranded (7/0·2), plasticcovered wire of the type used for equipment inter-board connections [1]. The feeder shown in the diagrams can be domestic quality 300Ω ribbon, since high power is unlikely to be used for portable operation. Generally speaking, the total weight of an assembled antenna, even for the lower frequency bands, should be no more than 150 – 200g. This weight will easily be supported by a kite whose surface area is around 0·5m^2 which leads us to the choice of kite.

Kite types

There are three main types of kite: the flat, or plane-surface kite; cellular kites (such as box kites), and the parafoil which has no rigid members and closely relates to the steerable parachute. All three types are equally suitable as supports for antennas, though their flying characteristics can be quite different. The most popular kite shape, and probably one of the easiest to construct, is the classic flat diamond with tail. Although simple to design, it can provide a very stable antenna support when correctly trimmed. It also has the merit of being relatively inexpensive to either buy or build. The diamond will fly in light to moderate winds and is easy to assemble and to fold. The more complex box kite will cope with stronger wind speeds and is an extremely stable flyer. It does not need a tail and, like the diamond, has a simple two-point bridle for attachment to its tether. Parafoil kites have air pockets which need to be inflated by the wind before they assume the aerofoil shape necessary to promote flight. For this reason they are more suited to moderate to strong winds, in which they exhibit an extremely high lift-to-weight ratio.

In selecting a kite, the main aim is to choose a stable design which will easily support the weight (and drag) of the chosen antenna and fly virtually motionless in a steady wind. The newcomer to kite flying is recommended to try a diamond for his first attempt. A relatively small one, with a surface area of only 0·5m^2 will easily lift 50m of thin antenna wire, and many toy shops stock such models which are usually made from plastic sheet. The "stunt" kites, with twin lines, should be avoided as they are not suitable for stable, anchored flight. Over-large kites should also be avoided. In a strong wind, a 2m^2 kite will exert a dramatically strong pull, with the attendant risks of a broken line or friction-burns to the hands! The more practically-minded reader may wish to build one of the excellent designs shown in books on the subject [2]. These give detailed information on the materials and construction methods to be used. Fortunately commercially-made kites are available and some sources are listed at the end of the article [3]. These kites are generally well made and require only a little "fine tuning" to the bridle to enable them to perform well. Whatever the source of a kite, it is a good idea to mark it with the owner's name and telephone number. A broken line can result in a kite travelling a considerable distance before grounding and it may be very difficult to find.

Clearly, broken lines are to be avoided, since a runaway kite with trailing line or antenna wire is potentially dangerous. It is therefore advisable to use a line which will not break, even in strong winds. Opinion varies as to the best type of line, but I favour monofilament nylon fishing line. This can be bought at modest cost from any fishing tackle shop and has the overriding advantage that it does not twist under strain. Various strengths are available, but 55lb breaking-strain sea fishing line is particularly suitable. It is usually sold on 100m plastic reels, but these are of no use for letting-out or reeling-in kite line in the field. Instead a purpose-built reel should be made, preferably with ball-race bearings and a winding handle, which is large enough to permit winding-in against a strong wind. Again, most books about kites also include diagrams of line reels, while an alternative approach might be to use a converted sea-fishing reel. If line other than monofilament nylon is used, there is a strong likelihood that it will twist in use. This can lead to tangles and knots which may be impossible to unravel. The solution is to use swivel-links of the appropriate strength at the kite end of the line. These are also available from fishing tackle shops. Before leaving the subject of fishing tackle, there is a definite art to tying knots in monofilament line, which will not slip apart or cause the line to be weakened. Any fisherman will be more than pleased to teach this skill, which is well worth acquiring!

Choice of site

The correct choice of site will contribute both to the success and to the safety of kite-borne antenna operation. The first, mandatory, requirement (see "Regulations" section) is that the site must be at least 5km (approximately three miles) from any operational airfield. It should also be well away from any area known to be used for low-level military flying, (see "Safety" section). It should be an open location, such as moorland or a hill or cliff top, although height for its own sake is not of course necessary at hf. The area should be as flat as possible and free from roads, buildings, trees and other objects, so as to allow easy retrieval of the kite if the wind should fail. It is also imperative that there should be no power lines of any sort anywhere near the chosen position (see "Safety" section). In this context, there should also be no folds or dips in the ground, or hedges, which might conceal power lines. Nor should the site be anywhere near a railway line (which might be electrified). In short, the ideal spot is large, flat and devoid of any features other than short grass! An Ordnance Survey map of the locality is often a useful source of ideas for potential sites, such as disused airfields, common ground, etc.

If there is uncertainty about the right to fly kites on a given site, it is wise to establish who owns the land and whether or not permission is needed. Care should also be taken to ensure that livestock is neither harmed nor frightened by the activity and that all equipment and stray bits of wire and rubbish are removed from site upon departure. Having listed several "negatives" it is worth pointing out at this stage the delights of operating far from the nearest source of man-made electrical noise. The improvement in signal-to-noise ratio is startling! If the chosen site allows vehicle access to the point where operation is to take place, so much the better. A car provides shelter, a power source and an equipment platform, all in one. It can also be used as the anchoring point for the simple antenna shown in Fig 1(a). If the vehicle battery is used as the equipment power source it is advisable to park on a downward slope if possible, to avoid the consequences of a 'flat' battery!

Kite-flying technique

Having chosen an antenna, a kite and a suitable location, it is best to wait for the right wind conditions for the maiden flight. Ideally the wind should be steady, rather than gusting, and of moderate strength. Wind speeds in the range 30 to 60km/h (approximately 20 to 40mph) would be suitable. The BBC TV weather forecasts provide excellent predictions of local wind speed and direction, subject to the normal uncertainties of any forecast of course. It should also be remembered when deciding whether to set out on a portable expedition that the wind will usually be stronger and steadier on a hill-top or open common than it appears to be at the home QTH. It may be preferable to take along an assistant on the first few outings, as single-handed kite launching can be a little tricky for the inexperienced flyer. "Junior ops" have a major advantage over one's spouse in this regard, in that they provide a plausible excuse if passers-by should wonder at the sight of an adult "playing with kites"! Until experience has been gained, kite flying in very strong winds should be

avoided. It is also a good idea, whatever the wind strength, to wear strong leather gloves while launching and recovering, as friction burns and even cuts to the fingers can be sustained when handling monofilament nylon under tension.

On arrival at site, the first task should be to prepare the antenna by laying it out on the ground ready for lifting as the kite rises. The anchoring point(s) should next be prepared, as it is difficult if not impossible to hammer stakes into the ground with one hand while fighting to hold a kite line in the other! Suitable anchoring points include a car roof-rack, bumper bar or towing-bracket, a convenient fence or post, or a purpose-made metal stake which can also be used as the earth connection. The kite should then be assembled and attached to its line. A metal ring should be inserted or tied in the kite line, some distance along from the kite itself, to which the antenna can be fastened. This ensures that the antenna hangs well below the kite, so it does not interfere with its launching or flying characteristics. The distance to the ring is not critical and will depend upon the total length of the line and of the antenna, but a minimum separation of 8 to 10m is suggested. This separation will also allow the kite to climb to a stable height before it has to start lifting the weight of the antenna. In cases (for higher frequency antennas perhaps) where the total antenna length/height is small, it is recommended that the antenna support ring is positioned tens of metres below the kite, allowing it to rise into steady wind conditions, despite the short antenna length.

After the antenna has been tied on, the kite can be launched. The assistant should hold the kite into the wind and 3 or 4m of line should be let out. Once the kite has been thrown upwards and has started to climb, more line should be released in a controlled manner to encourage it to climb quickly above ground turbulences. When the kite has attained sufficient altitude and is flying steadily, the antenna guys and anchoring points can be attended to, and finally the rig connected and powered up. It is wise, once radio operation has begun, to keep an eye on both the kite and the weather. Slowly declining signals may indicate a sinking kite rather than deteriorating band conditions! Similarly, the wind direction can shift quite rapidly and affect the performance of a directional aerial. A literal "weather eye" should be kept open for developing storm conditions which might pose the risk of lightning (see "Safety" section). These warnings may appear self-evident and unnecessary, but attention can become totally concentrated on operation of the equipment, particularly when "head down" in a contest or when kite-borne operation leads to the station becoming the subject of a "pile up".

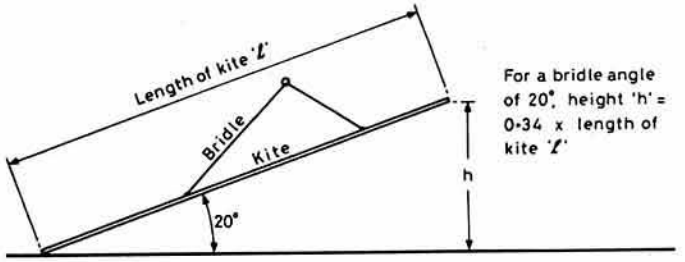

Fig 2. Method of adjusting bridle angle

Varying wind strengths may require adjustment to the bridle of the kite in order to achieve and maintain stable flight. Under moderate wind conditions a bridle angle of 20° makes a good starting point. In lighter winds this angle may need reducing, while stronger winds would require a larger angle. There are no hard-and-fast rules, and the optimum angle is dependent upon the flying characteristics of the individual kite, as well as upon wind strength. The method of adjusting the bridle angle, on a flat kite, to 20° is shown in Fig 2. The kite should be suspended by its bridle over a flat surface until its lowest point just touches. The angle between the kite and the flat surface should be adjusted to 20° by moving the support point along the bridle until the kite hangs correctly. If no convenient means exists to measure the angle directly, it can be calculated using the formula shown. An excellent idea is to fix a bridle ring (key rings are ideal) at the optimum point on the bridle to suit moderate winds, by a process of trial and error out in the field. Two other rings can then be positioned a few centimetres on either side of the first ring, for use in stronger and in weaker winds. The kite line is then terminated in a quick-release clip of the type used on dog-leads, enabling it to be easily changed from one ring to another.

CAA regulations

The flying of kites, which are classified as "aircraft" under current legislation, is governed by a number of rules, and full details of these regulations can be obtained by writing to the Civil Aviation Authority [4]. The main provisions of the legislation, affecting the use of kites for supporting antennas are as follows. First, kites should not weigh more than 2kg (4.5lb), but this is highly unlikely for the type and size of kite needed to lift light wire antennas. Second, kites must not be flown higher than 60m (197ft) above ground. This rule should not unduly handicap the erection of effective antennas, since a 5λ/8 vertical for 3·5MHz is only 50·5m (166ft) high. Third, kites should not be flown within 5km (3 miles) of an aerodrome or within 60m (197ft) of any vessel, vehicle or structure. Interestingly, permission may be granted by the CAA to operate outside the above restrictions provided that a written request is made to them specifying the purpose, precise location, proposed maximum height and period of time for which the kite is to be flown. Thus the height limitation (for those wishing to erect a half-wave vertical for 1·8MHz, for example) may not be totally binding. Unfortunately, the CAA requires that written application for an exception to the rules should be made about a month prior to the date of intended operation. The accurate prediction of wind conditions a month ahead of time is a skill which few radio amateurs possess, so this part of the regulations seems rather curious and of dubious value. However, operation entirely within the CAA regulations gives plenty of scope for worthwhile experimentation and should not prove to be any real hindrance.

Safety

Certain references have already been made to the question of safety while flying kite-borne antennas. The safest bet is never to fly kites anywhere in sight of power lines or railways. Always use tethering lines which have a wide margin of strength for the kite size and prevailing wind conditions. A runaway kite, trailing a wire antenna beneath, could travel a considerable distance before coming to earth and the wire could drape across power lines in the meantime. This could literally be lethal to anyone approaching the hanging, energised wire, especially to children who would not recognise the danger. The strength of a kite line can be judged by hanging a weight from a short length of it and jerking the line up and down. The "55lb" sea-fishing line mentioned earlier is adequately strong, yet thin and light to handle and is therefore recommended.

Kite flying should not be undertaken in areas where low-level military flying occurs. Military aircraft are authorised to fly down to 250ft above ground, at speeds which may reach 500mph. At these speeds, over undulating ground, they may inadvertantly fly even lower and contact with a kite-borne antenna system would obviously be catastrophic. If in doubt about the likelihood of low-level flying in a given area, one should make enquiries to the nearest military airfield.

The other danger is that of a lightning strike. Kites should never be flown in thundery weather conditions, and the first, distant roll of thunder should be the signal to immediately stop operating and reel-in the kite. Benjamin Franklin got away with it – you might not! A medium-wave broadcast receiver, such as a car radio, can be used to check for approaching thunderstorms, because the static "crashes" will be picked up when the storm is still many miles away. Even on days when there are no storms, large static charges can build up on a kite antenna unless there is a dc path for them to leak away to ground. Such charges can be extremely painful, if the only available leakage path is via a part of one's anatomy! So do fit a leak resistor to the atu, as described earlier.

In conclusion

Kite-borne antennas add a new dimension to portable hf operation and can dramatically improve reception and transmission compared with more conventional portable antennas. For the QRP enthusiast they offer a means of optimising low-power operation in the field.

Notes and references

[1] Available from Maplin Electronic Supplies Ltd.

[2] *Penguin Book of Kites*, David Pelham.

"Kite Antennas for Top Band", P Painting, G3OUC. *Practical Wireless* January 1984.

How to Make and Fly Kites, Eve Barwell and Conrad Bailey.

[3]Brookite Ltd, Okehampton, Devon EX20 1RR.

Ballons 'n' Things, 27 Essex Street, Birmingham 3.

Cochranes of Oxford Ltd, Leafield, Oxford OX8 5NT.

[4]Civil Aviation Authority, Room 621, Aviation House, 129 Kingsway, London WC2B.

Acknowledgements

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